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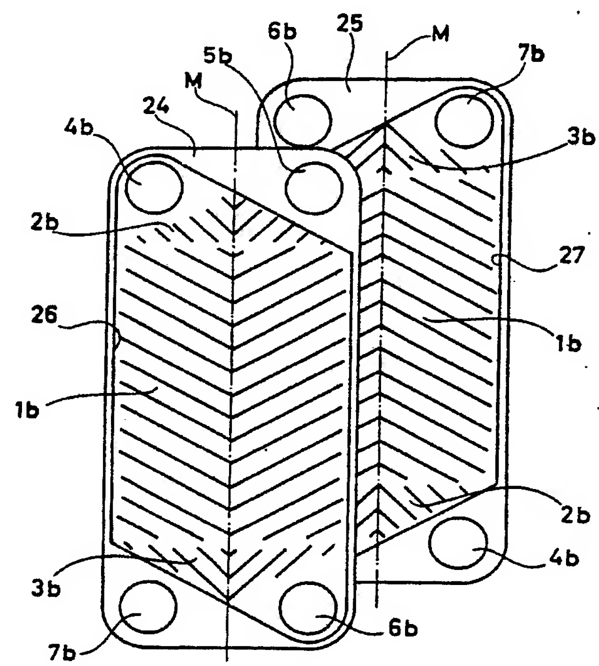
(54) Title: HEAT EXCHANGER PLATE

(57) Abstract

A heat exchanger plate has a primary heat exchange part (1b), two secondary heat exchange parts (2b, 3b) placed on each side of this one and four holes or ports (4b, 5b, 6b, 7b). Two of the ports are located at one of the secondary heat exchange parts in the same distance from but on each side of a centre line (M) of the plate. The two other ports are in a corresponding way located at the other secondary heat exchange part. The plate has in all heat exchange parts (1b, 2b, 3b) ridges and valleys embossed into it, which are so placed that when two plates are put against each other - one of them turned 180° relative to the other one - ridges in one plate intersectingly rest against ridges in the other plate. At least the ridges and the valleys in the secondary heat exchange parts (2b, 3b) are so embossed that they have a volume of essentially the same size on respective sides of the plate. In a plate of this kind each of the two secondary heat exchange parts is provided with ridges and valleys forming an angle with the centre line (M) of the plate. This angle (or these angles) differs from the angle (the angles) which the ridges and the valleys in the primary heat exchange part (1b) of the plate form with the centre line (M). Furthermore, the ridges and valleys of the plate form such angles with the centre line (M) that in a plate interspace they bring about less flow resistance in the areas of the secondary heat exchange parts (2b, 3b) of the plates - on both sides of the centre line (M) - than in the area of the primary heat exchange part (M) of the plates.



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Heat exchanger plate

This invention relates to a heat exchanger plate of the kind having a centrally placed primary heat exchange part, two secondary heat exchange parts placed on each side of this one and four holes or ports which are located two and two at the respective secondary heat exchange parts and of which the two ports at each of the secondary heat exchange parts are placed in the same distance from but on different sides of a centre line of the heat exchanger plate.

Heat exchanger plates of this kind being manufactured of a relatively thin plate are intended to be a part of a plate heat exchanger, essentially comprising a great number of such heat exchanger plates, which are kept together in a frame with a great pressure between two thicker end plates. Two heat exchange media are intended to flow through the plate interspaces accordingly created, to and from which they are conducted through channels formed by the ports in the heat exchanger plates which ports are placed in line with each other. In the plate interspaces gaskets or other means are arranged for tightening between the heat exchanger plates so that passages delimited from the environment are created for the heat exchange media.

In each plate interspace the heat exchange medium in question can flow either diagonally over the heat exchanger plates or essentially parallel with two sides of the plates. This invention relates to the first mentioned case and for this reason the heat exchanger plate according to the invention in a known way is provided with a gasket or the like which surrounds all three heat exchange parts and two diagonally placed ports.

In the heat exchanger plate according to the inventon the primary heat exchange part as well as the secondary heat exchange parts are further in a known way provided with ridges and inter-

mediate valleys embossed in the plate, which are so placed that when two plates are put against each other - one of them turned 180° relative to the other one - ridges in one plate intersectingly rest against ridges in the other plate. At least the ridges and valleys in the secondary heat exchange parts are so embossed that they have a volume of essentially the same size on respective sides of the plate.

A heat exchanger plate of the above described kind is previously known by the Swedish patent 342.691. In this plate in one of the secondary heat exchange parts the ridges and valleys form the same angles (60° and 120°) with the centre line of the plate as the ridges and the valleys in the primary heat exchange part, while in the other secondary heat exchange part the ridges and the valleys extend parallel with the mentioned centre line.

The purpose of the special design of the ridges and the valleys in the other secondary heat exchange part is, according to the patent, to bring about a reduced flow resistance for a heat exchange medium which via a port enters a plate interspace formed by two equal plates of this kind in the area closest to the mentioned port, i.e. where the through-flow area for the heat exchange medium is essentially less than in the area for the primary heat exchange parts of the two plates.

It is correctly stated in the patent that, in a conventional way designed heat exchanger plates, the flow resistance in the mentioned area closest to the inlet port gets an unwished size and cannot be effectively utilized for the heat exchange itself. The case will be the same on the opposite side of the primary heat exchange part in the area closest to the outlet port.

The purpose with this invention is to improve the efficiency of a heat exchanger plate of the kind mentioned by way of introduction, with other words to bring about such a design of the heat

exchanger plate that in a plate interspace formed by two equal plates - one of them turned 180° relative to the other one - arising flow resistance for a heat exchange medium is effectively utilized for the heat exchange itself than in a plate interspace formed by means of previously known heat exchanger plates.

This purpose is according to the invention attained in that way that each of the two secondary heat exchange parts at least on one side of the mentioned centre line of the plate is provided with ridges and valleys forming an angle with the centre line, that mentioned ridges and valleys in each of the secondary heat exchange parts form another angle, or other angles, with the centre line of the plate than the ridges and valleys in the primary heat exchange part, and that the ridges and the valleys of the plate form such angles with the centre line of the plate that when two plates are put against each other - one of them turned 180° relative to the other one - the ridges in the plate interspace intersecting and touching each other bring about a less flow resistance per unit of length in intended flow direction in the areas for the secondary heat exchange parts - on both sides of mentioned centre line - than in the area for the primary heat exchange parts.

Due to this different design of the two secondary heat exchange parts of a plate according to the invention in comparison with the design of corresponding parts of a plate according to the above mentioned Swedish patent No. 342.691, it has appeared to be possible in a plate interspace to receive a particularly favourable flow over the plates of entering heat exchange medium so that the secondary heat exchange parts of the plates are utilized in an effective way for the heat exchange not only in the proximity of the port through which the heat exchange medium enters the plate interspace but also on the opposite side of the mentioned centre line of the plate. When designing the secondary

heat exchange parts in accordance with the mentioned Swedish patent, it has appeared that such a favourable flow does not come about due to the fact that the reduced flow resistance which has been able to be received in a plate interspace in the area closest to the actual inlet port has received no correspondence in the area on the opposite side of the centre line of the plate.

The invention shall be described more closely in the following with reference to the accompanying drawing.

Fig. 1 illustrates a so-called diagonal flow of two heat exchange media on respective sides of a heat exchanger plate.

Fig. 2 shows two heat exchanger plates according to a first embodiment of the invention.

Fig. 3 shows a cross-section along the line III-III in Fig. 2.

Fig. 4 and Fig. 5 illustrate how ridges designed in different ways in two plates put against each other intersect each other in a plate interspace.

Fig. 6 shows two heat exchanger plates according to a second embodiment of the invention.

In Fig. 1 is schematically shown a heat exchanger plate with a primary heat exchange part 1, two secondary heat exchange parts 2, 3 and four holes going through the plate or so-called ports 4, 5, 6 and 7. Two full-drawn lines 8 and 9 illustrate how a first heat exchange medium is intended to stream on one side of the plate from the port 4 to the diagonally positioned port 6, while two broken lines 10 and 11 illustrate how a second heat exchange medium is intended to stream on the other side of the plate from the port 7 to the port 5.

The flow of two heat exchanging media illustrated in Fig. 1 is usually called diagonal flow.

In Fig. 2 there are shown two heat exchanger plates 12 and 13 equally embossed. One plate is turned 180° in its own plane relative to the other one. Each plate 12 and 13, respectively, has a primary heat exchange part 1a, two secondary heat exchange parts 2a and 3a, respectively, and four ports 4a, 5a, 6a and 7a. On the side of the plate 12 visible in Fig. 2 all the three heat exchange parts 1a, 2a and 3a together with the ports 4a and 6a are surrounded by a gasket 14 arranged in a groove embossed in the plate. Separate gaskets (not shown in the drawing) surround respective ports 5a and 7a. In the plate 13 all the three heat exchange parts 1a, 2a and 3a together with the ports 5a and 7a are in a corresponding way surrounded by a gasket 15.

In the primary heat exchange part 1a the plate 12 and 13, respectively, has a corrugation pattern of ridges and valleys brought about by embossing. The pattern is symmetrical round a centre line M in the plate and forms such angles relative to this centre line that in an interspace between two adjacent plates arranged as in Fig. 2 the ridges in one plate may intersectingly rest against the ridges in the other plate.

Even the secondary heat exchange parts 2a and 3a in the plates 12 and 13 have ridges and valleys which form such angles with the centre line M that in a plate interspace according to Fig. 2, ridges in the part 2a of one plate can rest intersectingly against ridges in the part 3a of the other plate.

The ridges and valleys in the primary heat exchange part 1a of the plates 12 and 13 form an angle of about 60° with the centre line M on one side of this one and an angle of about 120° with the centre line M on the other side of this one. In the secondary heat exchange part 2a, the ridges and valleys

form an angle of about 45° with the centre line M, while corresponding angle is about 135° in the secondary heat exchange part 3a.

As is apparent from Fig. 1 one of the heat exchanging media streams essentially cross the flow direction for the second medium on each side of the secondary heat exchange parts of the plate. If the same flow conditions are wished for both heat exchange media it is necessary, when having plates intended for diagonal flow that the ridges and the valleys in the secondary heat exchange parts are given such a design that they have a volume of essentially the same size on respective sides of the plate.

This is illustrated by Fig. 3 which is a sectional view along the line III-III in Fig. 2. In Fig. 3 there are shown two planes 16 and 17 located through the tops of the ridges formed on each side of a plate. The enclosed volume between the plane 16 and two adjacent ridges on one side of the plate shall accordingly be essentially as large as the volume between the plane 17 and two adjacent ridges on the other side of the plate.

In Fig. 4 is illustrated how ridges designed in the secondary heat exchange part 2a of the plate 12 intersect ridges designed in the secondary heat exchange part 3a of the plate 13 when the plates 12 and 13 are arranged for forming a plate interspace in accordance with Fig. 2.

In Fig. 5 the same thing is illustrated regarding the ridges designed in the primary heat exchange parts 1a of the plates 12 and 13.

In Fig. 4 different flow directions for a heat exchange medium have been indicated by means of arrows 18, 19 and 20. There are corresponding arrows 21, 22 and 23 in Fig. 5.

It is generally known how the flow resistance for a heat exchange medium varies in a plate interspace depending on the extension of the ridges designed in the plates in relation to the flow direction of the heat exchange medium. When the ridges, as is illustrated in Fig. 4, in two adjacent plates intersect each other under formation of essentially right angles (90^o), there arises, of course, a flow resistance for a flow with the direction 18 as large as for a flow with the direction 20. For a flow with the direction 19, however, in this case a flow resistance arises essentially as large as for flows with the directions 18 and 20.

When the ridges in two adjacent plates intersect each other with the angles as appear from Fig. 5, the flow resistances are very unlike depending on the flow direction. For a flow with the direction 21 the flow resistance accordingly becomes several times as large as for a flow with the direction 23. For a flow with the direction 22 the flow resistance becomes something therebetween. The flow resistance in a plate interspace according to Fig. 5 for a flow with the direction 21 becomes also essentially larger than the flow resistance in a plate interspace according to Fig. 4 irrespective of the direction of the flow in that interspace.

Thus, it is possible, by suitably choosing the directions of the ridges embossed in the plates in relation to the intended flow directions for the heat exchanging media, to get wished flow resistance for these media in different parts of a plate interspace.

In the heat exchange plates 12 and 13 in Fig. 2 this fact has had the following consequence. A heat exchange medium entering the interspace between the plates via the port 7a of the plate 13 (or via the port 5a of the plate 12) meets a relatively small flow resistance in whole that part of the plate interspace for-

med by the part 2a of the plate 12 and the part 3a of the plate 13.

This has the consequence that the different branch flows of the heat exchange medium reaching the primary heat exchange parts 1a of the plates, which parts 1a cause essentially larger flow resistance than the secondary heat exchange parts 2a and 3a, are of essentially the same size. The consequence of that is that the secondary heat exchange parts of the plates as well as the primary heat exchange parts in their entirety are utilized in an effective way, i.e. the pressure drop that the heat exchange medium totally undergoes during its passage through the plate interspace is utilized as far as possible for the heat exchange itself.

In Fig. 6 there are shown two heat exchange plates 24 and 25 equally embossed. The only thing that differs these plates from the plates 12 and 13, respectively, in Fig. 2 is the design of the secondary heat exchange parts of the plates. The different heat exchange parts of the plates 24 and 25 have been denoted 1b, 2b and 3b in Fig. 6. The ports of the plates have been denoted 4b, 5b, 6b and 7b, and two gaskets have been denoted 26 and 27, respectively.

As is apparent, the ridges and the valleys in each of the secondary heat exchange parts 2b and 3b are symmetrically designed with regard to the centre line M of the plates. On one side of the centre line M the ridges form an angle of about 45^{o} with the centre line M in the part 2b as well as in the part 3b, while on the other side of the centre line M the ridges in both parts 2b and 3b form an angle of about 135^{o} with the centre line.

The different design of the secondary heat exchange parts of the plates 24 and 25 does not materially influence the flow resis-

tance received in a plate interspace formed by these plates in comparison with the flow resistance received in a plate interspace formed by the plates 12 and 13 in Fig. 2. On one side of as well as on the other side of the centre line M the ridges in the secondary heat exchange parts of the plates will intersectingly rest against each other under right angles and in both cases the ridges of one plate form an angle of 45° and the ridges of the other plate an angle of 135° with the centre line M of the plates.

An advantage with the design of the secondary heat exchange parts as they are shown in Fig. 6 is that the above described advantageous flow can be brought about between the plates 24 and 25 even if the plate 25 should be turned 180° round its centre line M, i.e. should be turned with its reverse side against the reverse side of the plate 24. This can come into question if the tightening between the plates 24 and 25 shall be brought about by soldering or welding instead of a rubber gasket.

The division of the embossing pattern in the secondary heat exchange part is in both embodiments according to Figs. 2 and 6 essentially the same as that of the embossing pattern in the primary heat exchange part.

The two different embodiments of the secondary heat exchange parts appearing from Figs. 2 and 6 are not the only ones possible within the scope of the present invention, as this one is stated in the following claims.

By way of an example, in each of the secondary heat exchange parts the ridges on one side of the centre line M can form an angle of 90° with this one, while the ridges on the other side of the centre line M form another angle or extend parallel with this one.

Claims

1. Heat exchanger plate having a centrally placed primary heat exchange part (1), two secondary heat exchange parts (2, 3) placed on each side of this one and four holes or ports (4-7) which are located two and two at the respective secondary heat exchange parts and of which the two parts at each of the secondary heat exchange parts are placed in the same distance from but on different sides of a centre line (M) of the heat exchanger plate,
- the primary heat exchange part (1) as well as the secondary heat exchange parts (2, 3) having ridges and intermediate valleys embossed in the plate which are so placed that when two plates are put against each other - one of them turned 180° relative to the other one - ridges in one plate intersectingly rest against ridges in the other plate, and
- the ridges and the valleys in at least the secondary heat exchange parts (2, 3) being so embossed that they have a volume of essentially the same size on respective sides of the plate,
c h a r a c t e r i z e d i n
- that all heat exchange parts (1-3) together with two diagonally placed ports (4, 6; 5, 7) are surrounded by a gasket or the like arranged to tighten between two plates put against each other, accordingly delimiting a passage for a heat exchange medium between the plates,
- that each of the two secondary heat exchange parts (2a, 3a; 2b, 3b) at least on one side of the mentioned centre line (M) of the plate is provided with ridges and valleys forming an angle with the centre line,
- that mentioned ridges and valleys in each of the secondary heat exchange parts (2a, 3a; 2b, 3b) form another angle, or other angles, with the centre line (M) of the plate than the ridges and the valleys in the primary heat exchange part (1a; 1b), and

- that the ridges and the valleys of the plate form such angles with the centre line (M) of the plate that when two plates are put against each other - one of them turned 180° relative to the other one - the ridges in the plate interspace intersecting and touching each other bring about a less flow resistance per unit of length in intended flow direction in the areas for the secondary heat exchange parts (2a, 3a: 2b, 3b) - on both sides of mentioned centre line (M) - than in the area for the primary heat exchange parts (1a; 1b).

2. Heat exchanger plate according to claim 1, c h a r a c t e r i z e d i n that the ridges and the valleys have such extension in the plate that when two plates are put on each other - one of them turned 180° in relation to the other one - the ridges in the secondary heat exchange parts (2a, 3a; 2b, 3b) touching each other intersect each other under other angles than the ridges in the primary heat exchange parts (1a; 1b).

3. Heat exchanger plate according to claim 2, c h a r a c t e r i z e d i n that the ridges and the valleys in the primary heat exchange part (1a; 1b) form an angle of the size of 60° (120°) with the centre line (M) of the plate, while the ridges and the valleys in the secondary heat exchange parts (2a, 3a; 2b, 3b) form an angle of the size of 45° (135°) with the centre line (M) of the plate.

4. Heat exchanger plate according to anyone of the preceding claims, c h a r a c t e r i z e d i n that the ridges and the valleys extend in a first direction in the two halves of the secondary heat exchange parts (2b, 3b) located on one side of the centre line (M) of the plate but in another direction in the two other halves of the secondary heat exchange parts (2b, 3b).

5. Heat exchanger plate according to claim 4, c h a r a c t e r i z e d i n that the ridges and the valleys in each

of the secondary heat exchange parts (2b, 3b) are symmetrically embossed with regard to the centre line (M) of the plate.

6. Heat exchanger plate according to anyone of the preceding claims, c h a r a c t e r i z e d i n that the division of the embossing pattern in the secondary heat exchange part is essentially the same as that of the embossing pattern in the primary heat exchange part.

Fig.1

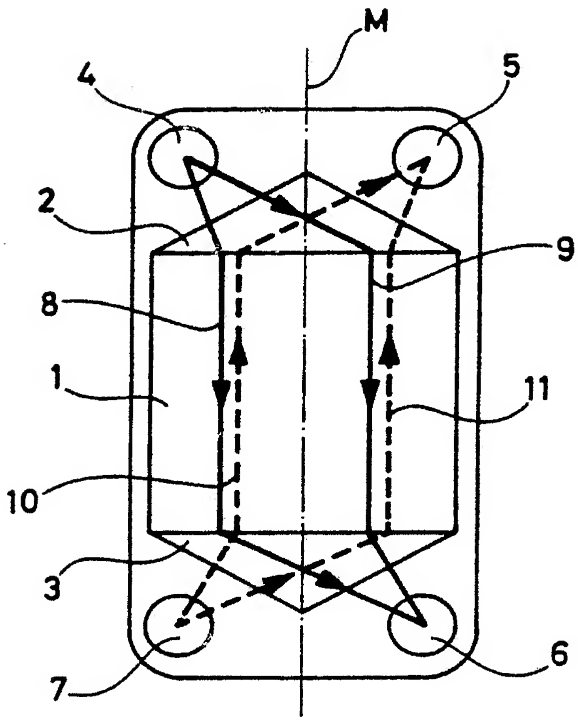


Fig. 2

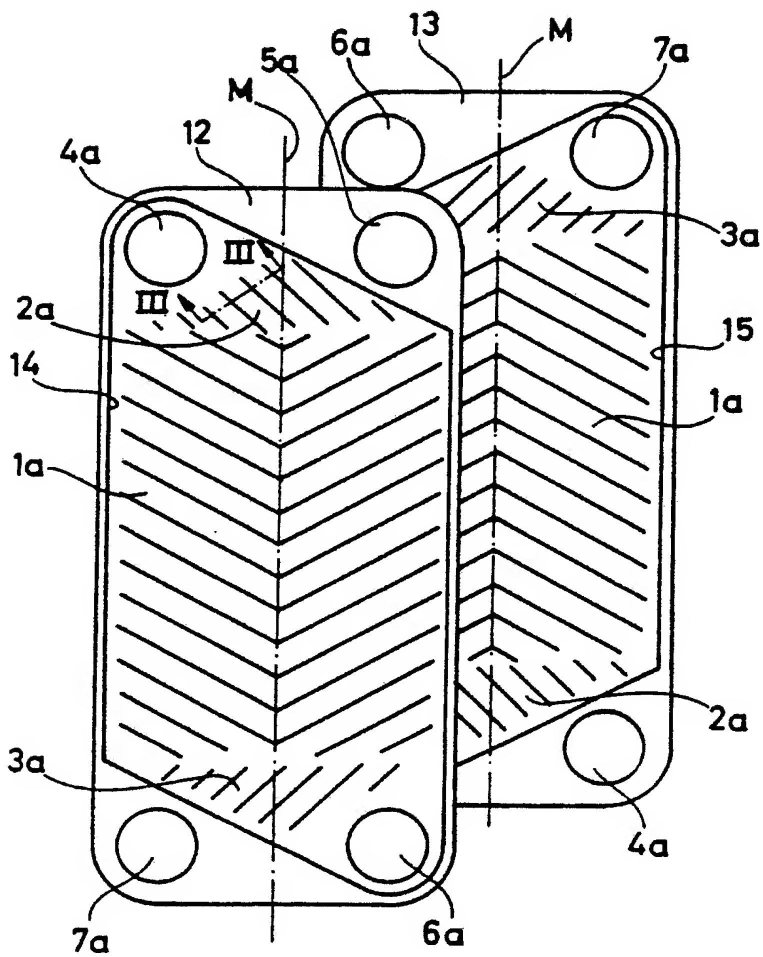
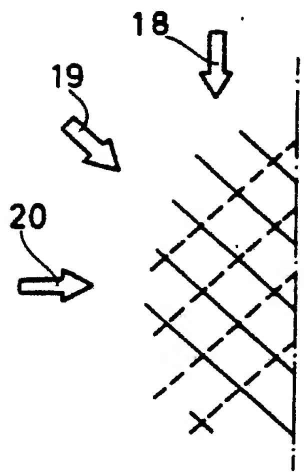
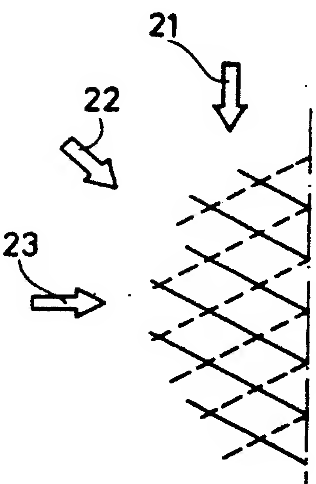


Fig. 4



45°/ 135°

Fig. 5



60°/ 120°

Fig. 3

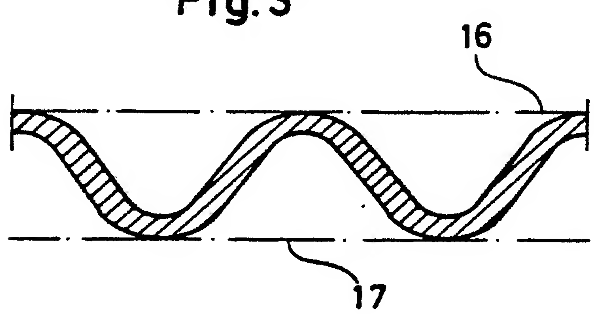
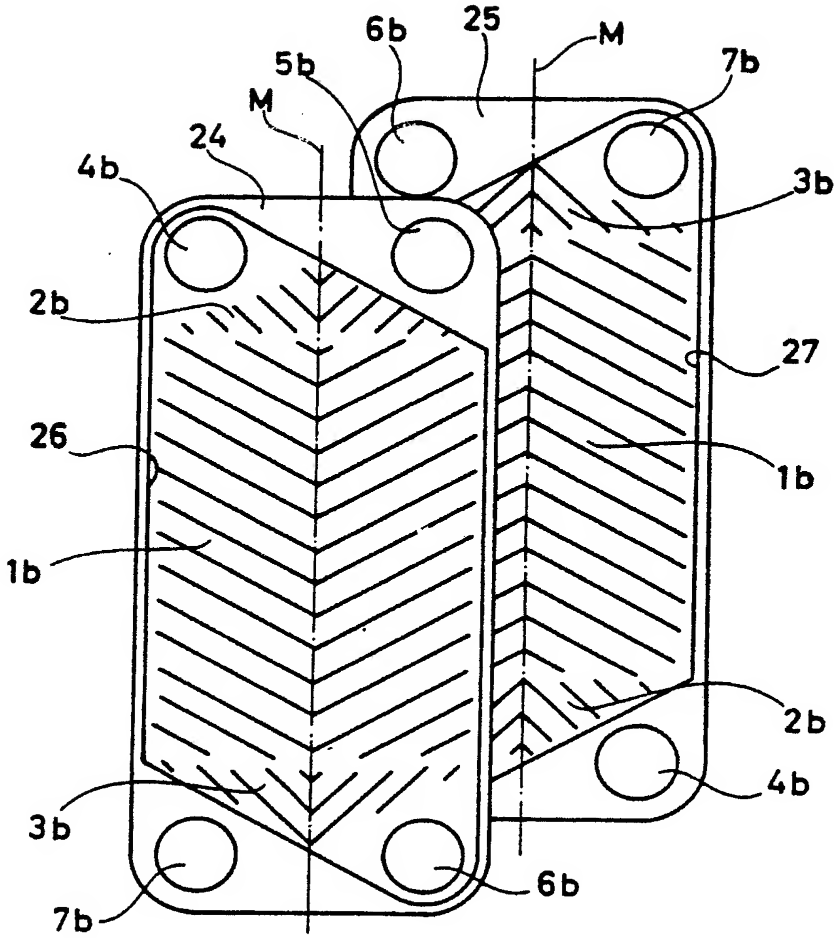


Fig.6



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE84/00413

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[3]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

F 28 F 3/00

II. FIELDS SEARCHED

Minimum Documentation Searched[4]

Classification System	Classification Symbols
IPC 3	F 28 F 3/00,08,10; F 28 D 9/00
Nat Cl	17f:5/30; 53e:2
US Cl	165:166, 167

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[14]

Category*	Citation of Document,[16] with indication, where appropriate, of the relevant passages[17]	Relevant to Claim No.[18]
Y	SE, B, 342 691 (UKRAINSKY NAUCHNOISSLEDOVATELSKY KONSTRUKTORSKY INSTITUT KHIMICHESKOGO MASHINOSTROENIA, KHARKOV) 22 July 1971	1, 2, 4, 5, 6
A	SE, B, 7900410-7 (ALFA-LAVAL AB) 18 July 1980	1-6
Y	SE, B, 7807677-5 (ALFA-LAVAL AB) 11 January 1980	1, 3, 6
Y	DE, A, 2 109 346 (THE A P V CO LTD) 14 October 1971 & GB, 1339542	1, 5, 6
A	DE, A1, 2 552 335 (VEB COMBINAT IMPULSA BETRIEB VEB KYFFHÄUSERHYTTE ARTERN) 8 June 1977	1-6
A	DE, A1, 2 704 183 (H FISCHER) 18 August 1977	1-5

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IV. CERTIFICATION

Date of the Actual Completion of the International Search[2]	Date of Mailing of this International Search Report[2]
1985-02-18	1985-02-21
International Searching Authority[1]	**Signature of Authorized Officer**[20]
Swedish Patent Office	H. Gudmundsson Heléne Gudmundsson

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International Application No. PCT/SE85/00413

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	DE, A1, 3 141 161 (W SCMIDT GmbH & CO KG) 26 May 1983 & GB, 2107845 FR, 2514880 SE, 8205798	1, 2
Y	US, A, 3 807 496 (ALFA-LAVAL AB) 30 April 1974	1-5